Unfolding single-particle efficiencies and the Outer Tracker in LHCb

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Summary

This manuscript covers two very different topics within the context of the LHCb experiment. The first part focuses on the Outer Tracker subdetector, while in the second part a novel algorithm is developed to determine the experimental inefficiencies in measuring particles.

Part I, the Outer Tracker detector in LHCb

The Outer Tracker is a gaseous subdetector based on straw tube technology, that is part of the LHCb tracking system. The Outer Tracker detector modules and support frames had been constructed in various places. Upon arrival at CERN they were subjected to a final set of quality control tests immediately prior to their installation into the LHCb experiment The gas distribution system, the high and low voltage supply systems and the optical readout were shown to be working within design specifications. Moreover, nearly half of the 53,760 thin straw tubes that constitute the Outer Tracker detection volume were individually tested with a radioactive iron source, with less than 0.1% unresponsive straws.

Signals from straw tubes are read out and processed by Front End electronics. Front End electronics boxes were assembled from the various specialized electronics components and tested for their defining characteristics. The threshold responses, time linearities, pipeline buffer synchronizations and noise levels were analyzed for each box and assured to be within specifications. The Differential Non-Linearity, an intrinsic feature of the electronics, was studied in detail and shown not to be a limiting factor on the Outer Tracker drift time resolution.

Part II, single-particle efficiencies from multi-body processes

A novel approach is developed to determine experimental inefficiencies in detecting particles. The approach chosen is based on multi-body control channels, i.e. on channels for which the underlying distribution of particles is well known. Such an approach, however, is complicated by inter-particle correlations, where particles do not only suffer from their own detection efficiencies, but because the multi-body process correlates the outgoing particles, they also suffer from each others detection efficiencies. This complication is addressed and solved with a method that iteratively unfolds the individual particle detection efficiencies from the multi-body topology.

This iterative method has been motivated by one of the key measurements of LHCb :